

1     Connection System for Subsea Flow Interface  
2     Equipment

3

4     This invention relates in general to subsea well  
5     production, and in particular to a connection system  
6     for connecting flow interface equipment, such as a  
7     pump to a subsea Christmas tree assembly.

8

9     A subsea production facility typically comprises a  
10    subsea Christmas tree with associated equipment.

11    The subsea Christmas tree typically comprises a  
12    choke located in a choke body in a production wing  
13    branch. There may also be a further choke located  
14    in an annulus wing branch. Typically, well fluids  
15    leave the tree via the production choke and the  
16    production wing branch into an outlet flowline of  
17    the well. However, in such typical trees, the  
18    fluids leave the well unboosted and unprocessed.

19

20    According to a first aspect of the present invention  
21    there is provided an apparatus for connecting to a

1 subsea wellbore, the wellbore having a manifold and  
2 a choke body, the apparatus comprising:

3 a frame adapted to land on the manifold;

4 a conduit system having a first end for  
5 connection to the interior of the choke body and a  
6 second end for connection to a processing apparatus;

7 wherein the conduit system comprises a conduit  
8 means supported by the frame;

9 wherein the frame comprises at least one frame  
10 member that is adapted to land on the manifold in a  
11 first stage of the connection and wherein the  
12 conduit means is adapted to be brought into fluid  
13 communication with the interior of the choke body in  
14 a second stage of the connection.

15  
16 The two-stage connection provides the advantage that  
17 damage to the mating surfaces between the conduit  
18 means and the flow line of the tree assembly can be  
19 avoided whilst the frame is being landed, since at  
20 least a part of the frame is landed before the  
21 connection between the conduit means and the  
22 interior of the choke body is made up. Hence, the  
23 two-stage connection acts to buffer and protect the  
24 mating surfaces. The two-stage connection also  
25 protects the choke itself from damage whilst the  
26 frame is being landed; in particular, the mating  
27 surface of the choke is protected.

28  
29 In some embodiments, processing apparatus e.g.  
30 multi-phase flow meters and pumps can be mounted on  
31 the frame and can be landed on the tree with the  
32 frame. Alternatively, the processing apparatus may

1 be located remote from the tree, e.g. on a further  
2 subsea installation such as a manifold or a pile,  
3 and the frame may comprise connections for jumper  
4 conduits which can lead fluids to and from the  
5 remote processing apparatus.

6  
7 The processing apparatus allows well fluids to be  
8 processed (e.g. pressure boosted/ injected with  
9 chemicals) at the wellhead before being delivered to  
10 the outlet flowline of the well. The invention may  
11 alternatively be used to inject fluids into the well  
12 using the outlet flowline as an inlet.

13  
14 Often the processing apparatus, e.g. subsea pump,  
15 flow meter, etc. is quite heavy and bulky. In  
16 embodiments where heavy/bulky apparatus is carried  
17 by the frame, the risk of damage to the mating  
18 surfaces between the conduit means and the flow line  
19 of the tree assembly is particularly great.

20  
21 Optionally, the apparatus further comprises an  
22 actuating means mounted on the frame, the actuating  
23 means being adapted to bring the conduit means into  
24 fluid communication with the interior of the choke  
25 body. Typically, the actuating means comprises at  
26 least one hydraulic cylinder. Alternatively, the  
27 actuating means may comprise a cable or a screw jack  
28 which connects the conduit means to the frame, to  
29 control the movement of the conduit means relative  
30 to the frame.

31

1 The conduit means is not necessarily brought into  
2 direct communication with the choke body. In some  
3 embodiments (the first embodiment and the third  
4 embodiment below), the conduit means is connected  
5 with the interior of the choke body via a further,  
6 secondary conduit.

7  
8 In a first embodiment, a mounting apparatus is  
9 provided for landing a flow interface device,  
10 particularly a subsea pump or compressor (referred  
11 to collectively at times as "pressure intensifier")  
12 on a subsea production assembly.

13  
14 Optionally, the at least one frame member of the  
15 first connection stage comprises a lower frame  
16 member, and the apparatus further comprises an upper  
17 frame member, the upper frame member and the lower  
18 frame member having co-operating engagement means  
19 for landing the upper frame member on the lower  
20 frame member.

21  
22 In the first embodiment, a secondary conduit in the  
23 form of a mandrel with a flow passage is mounted to  
24 the lower frame member. The operator lowers the  
25 lower frame member into the sea and onto the  
26 production assembly. The production assembly has an  
27 upward facing receptacle that is sealingly engaged  
28 by the mandrel.

29  
30 In this embodiment, the conduit means comprises a  
31 manifold, which is mounted to the upper frame  
32 member. The manifold is connected to a flow

1 interface device such as a pressure intensifier,  
2 which is also mounted to the upper frame member.  
3 The operator lowers the upper frame member along  
4 with the manifold and pressure intensifier into the  
5 sea and onto the lower frame member, landing the  
6 manifold on the mandrel. During operation, fluid  
7 flows from the pressure intensifier through the  
8 manifold, the mandrel, and into the flow line.  
9

10 Preferably, the subsea production assembly comprises  
11 a Christmas tree with a frame having guide posts.  
12 The operator installs extensions to the guide posts,  
13 if necessary, and attaches guidelines that extend to  
14 a surface platform. The lower and upper frame  
15 members have sockets with passages for the  
16 guidelines. The engagement of the sockets with the  
17 guide posts provides gross alignment as the upper  
18 and lower frame members are lowered onto the tree  
19 frame.  
20

21 Also, preferably the Christmas tree frame has upward  
22 facing guide members that mate with downward facing  
23 guide members on the lower frame member for  
24 providing finer alignment. Further, the lower frame  
25 member preferably has upward facing guide members  
26 that mate with downward facing guide members on the  
27 upper frame member for providing finer alignment.  
28 One or more locking members on the lower frame  
29 member lock the lower frame member to the tree  
30 frame. Additionally, one or more locking members on  
31 the upper frame member lock the upper frame member  
32 to the lower frame member.

1  
2     Optionally, the apparatus further comprises  
3     buffering means provided on the frame, the buffering  
4     means providing a minimum distance between the frame  
5     and the tree.

6  
7     The buffering means may comprise stops or adjustable  
8     mechanisms, which may be incorporated with the  
9     locking members, or which may be separate from the  
10    locking members.

11  
12    The adjustable stops define minimum distances  
13    between the lower frame member and the upper plate  
14    of the tree frame and between the lower frame member  
15    and the upper frame member.

16  
17    The buffering means typically comprise threaded  
18    bolts, which engage in corresponding apertures in  
19    the frame, and which can be rotated to increase the  
20    length they project from the frame. The ends of the  
21    threaded bolts typically contact the upper frame  
22    member of the tree, defining a minimum distance  
23    between the frame and the tree.

24  
25    Optionally, a further buffering means is provided  
26    between the lower and upper frame members to define  
27    a minimum distance between the lower and upper frame  
28    members. The further buffering means also typically  
29    comprises threaded bolts which extend between the  
30    lower and upper frame members. The extent of  
31    projection of the threaded bolts can be adjusted to

1 provide a required separation of the upper and lower  
2 frame members.

3  
4 The buffering means (e.g. the adjustable stops)  
5 provides structural load paths from the upper frame  
6 member through the lower frame member and tree frame  
7 to the tree and the wellhead on which the tree is  
8 mounted. These load paths avoid structural loads  
9 passing through the mandrel to the upward facing  
10 receptacle (i.e. the choke body).

11  
12 In a second embodiment, the frame is lowered as a  
13 unit, but typically has an upper portion (an upper  
14 frame member) that is vertically movable relative to  
15 the lower portion (a lower frame member). A  
16 processing apparatus (in the form of a pressure  
17 intensifier) and a conduit means (a mandrel) are  
18 mounted to the upper portion. An actuating means  
19 comprising one or more jack mechanisms is provided  
20 between the lower and upper portions of the frame.  
21 When the lower portion of the frame lands on the  
22 tree frame, the lower end of the mandrel will be  
23 spaced above the flow line receptacle. The jack  
24 mechanisms then lower the upper portion of the  
25 frame, causing the mandrel to stab sealingly into  
26 the receptacle (the choke body). Thus, in this  
27 embodiment, the conduit means comprises a single  
28 mandrel having a single flowpath therethrough.

29  
30 In a third embodiment, the conduit means has a  
31 flexible portion. Preferably, the flexible portion  
32 is moveable relative to the frame. Typically, the

1 flexible portion of the conduit means is fixed  
2 relative to the frame at a single point. Typically,  
3 the flexible portion of the conduit means is  
4 connected to the processing apparatus and supported  
5 at the processing apparatus connection, in  
6 embodiments where the processing apparatus is  
7 supported on the frame.

8  
9 Optionally, the conduit means comprises two  
10 conduits, one of which is adapted to carry fluids  
11 going towards the processing apparatus, the other  
12 adapted to carry fluids returning from the  
13 processing apparatus. Typically, each of the two  
14 conduits of the conduit means is fixed relative to  
15 the frame at a respective point. Typically, the  
16 flexible portion of each of the two conduits of the  
17 conduit means is connected to the processing  
18 apparatus and is supported at the processing  
19 apparatus connection (where a processing apparatus  
20 is provided on the frame).

21  
22 Typically, the flexible portion of the conduit means  
23 is resilient. Typically, the direction of movement  
24 of the flexible portion of the conduit means in the  
25 second stage of the connection defines an axis of  
26 connection and the flexible portion of the conduit  
27 means is curved in a plane perpendicular to the axis  
28 of connection to provide resilience in the  
29 connection direction. In such embodiments, the  
30 flexible portion of the conduit means is in the form  
31 of a coil, or part of a coil. This allows the lower



1 end of the conduit means (the connection end) to be  
2 moved resiliently in the connection direction.

3  
4 Typically, the flexible portion of the conduit means  
5 supports a connector adapted to attach to the choke  
6 body (either directly or via a further conduit  
7 extending from the choke body), the flexible portion  
8 of the conduit means allowing relative movement of  
9 the connector and the frame to buffer the  
10 connection.

11  
12 Typically, an actuating means is provided which is  
13 adapted to move the flexible portion relative to the  
14 frame to bring an end of the flexible portion into  
15 fluid communication with the interior of the choke  
16 body. The actuating means typically comprises a  
17 swivel eye mounting hydraulic cylinder.

18  
19 Considering now all embodiments of the invention,  
20 the conduit system may optionally provide a single  
21 flowpath between the choke body and the processing  
22 apparatus.

23  
24 Alternatively, the conduit system provides a two-  
25 flowpath system: a first flowpath from the choke  
26 body to the processing apparatus and a second  
27 flowpath from the processing apparatus to the choke  
28 body. In such embodiments, the conduit system can  
29 comprise a housing and an inner hollow cylindrical  
30 member, the inner cylindrical member being adapted  
31 to seal within the interior of the choke body to  
32 define a first flow region through the bore of the

1 cylindrical member and a second separate flow region  
2 in the annulus between the cylindrical member and  
3 the housing.

4

5 Typically, the first and second flow regions are  
6 adapted to connect to a respective inlet and an  
7 outlet of the processing apparatus.

8

9 Such embodiments can be used to recover fluids from  
10 the well via a first flowpath, process these using  
11 the processing apparatus (e.g. pressure boosting)  
12 and then to return the fluids to the choke body via  
13 a second flowpath for recovery through the  
14 production wing branch. The division of the inside  
15 of the choke body into first and second flow regions  
16 by the inner cylindrical member allows separation of  
17 the first and second flowpaths within the choke  
18 body.

19

20 If used, the housing and the inner hollow  
21 cylindrical member typically are provided as the  
22 part of the conduit system that directly connects to  
23 the choke body, i.e. in the first embodiment, this  
24 is the secondary conduit; in the second embodiment,  
25 the conduit means, and in the third embodiment, the  
26 secondary conduit.

27

28 Optionally, the processing apparatus is provided on  
29 the frame. In this case, the processing apparatus  
30 is typically connected to the conduit means before  
31 the frame is landed on the tree.

32

1 Alternatively, the processing apparatus is provided  
2 on a further subsea manifold, such as a suction  
3 pile. Jumper cables can be connected between the  
4 frame on the manifold and the further subsea  
5 manifold to connect the processing apparatus to the  
6 conduit system. In this case, the processing  
7 apparatus is typically connected to the conduit  
8 means as a final step.

9  
10 In all embodiments, the frame typically includes  
11 guide means that co-operate with guide means  
12 provided on the manifold, to align the frame with  
13 the manifold. The frame may also or instead  
14 comprise a guide pipe that surrounds at least a part  
15 of the conduit system, to protect it from impact  
16 damage.

17  
18 All embodiments use the space inside the choke body  
19 after the choke bonnet has been removed and the  
20 choke withdrawn. However, it may still be desirable  
21 to be able to use a choke to control the fluid flow.  
22 Optionally, a replacement choke is provided on the  
23 frame, the replacement choke being connectable to  
24 the conduit system.

25  
26 Embodiments of the invention can be used for both  
27 recovery of production fluids and injection of  
28 fluids.

29  
30 According to a second aspect of the present  
31 invention there is provided a method of connecting a  
32 processing apparatus to a subsea wellbore, the

1 wellbore having a manifold and a choke body, the  
2 method comprising:

3 landing a frame on the manifold and connecting  
4 a conduit system between the choke body and the  
5 processing apparatus, the frame supporting a conduit  
6 means of the conduit system;

7 wherein the frame comprises at least one frame  
8 member that is landed on the manifold in a first  
9 connection stage, and wherein the conduit means is  
10 brought into fluid communication with the interior  
11 of the choke body in a second connection stage.

12

13 The method typically includes the initial steps of  
14 removing the choke bonnet and connecting the  
15 secondary conduit to interior of the choke body.

16

17 The choke bonnet is removed and the secondary  
18 conduit may be installed by choke bonnet changing  
19 equipment (e.g. the third embodiment).

20 Alternatively, the secondary conduit may be  
21 supported on the lower frame member and may be  
22 installed when the lower frame member is landed on  
23 the manifold (e.g. the first embodiment).

24

25 According to a third aspect of the present invention  
26 there is provided an apparatus for connecting to a  
27 subsea wellbore, the wellbore having a manifold and  
28 a choke body, the apparatus comprising:

29 a frame having a conduit system, the frame  
30 being adapted to land on the tree, the conduit  
31 system including a first end which is adapted to  
32 connect to the choke body such that the conduit is

1 in fluid communication with the interior of the  
2 choke body, and a second end connectable to a  
3 processing apparatus;

4 wherein the frame comprises buffering means  
5 adapted to buffer the connection between the first  
6 end of the conduit system and the choke body.  
7

8 In the first embodiment, the buffering means may be  
9 provided by the adjustable stop means, which provide  
10 structural load paths from the upper frame member  
11 through the lower frame member and tree frame to the  
12 tree and the wellhead on which the tree is mounted  
13 which avoid structural loads passing through the  
14 mandrel to the choke body.  
15

16 In the second embodiment, the buffering means is  
17 typically provided by the arrangement of the upper  
18 and lower frame members, the upper frame member  
19 being moveable to lower the mandrel (the conduit  
20 means) into connection with the choke body in a  
21 controlled manner, only after the frame has been  
22 landed.  
23

24 In the third embodiment, the buffering means may be  
25 provided by the flexible portion of the conduit  
26 means, which allows movement of the conduit end that  
27 connects to the secondary conduit. Therefore, the  
28 connection end of the conduit means will not heavily  
29 impact into the secondary conduit as it is able to  
30 deflect as necessary, using the flexibility of the  
31 conduit means, and can optionally be manoeuvred for

1 even greater control (e.g. by an actuating  
2 mechanism).

3

4 According to a fourth aspect of the present  
5 invention there is provided an apparatus for  
6 connecting to a subsea wellbore, the wellbore having  
7 a manifold and a choke body, the apparatus  
8 comprising:

9 a frame adapted to land on the manifold;

10 a conduit system having a first end for  
11 connection to the choke body and a second end for  
12 connection to a processing apparatus;

13 wherein at least a part of the conduit system  
14 is supported by the frame;

15 wherein the conduit system comprises at least  
16 one flexible conduit having an end that is moveable  
17 relative to the frame to make up a communication  
18 between the processing apparatus and the choke body.

19

20 In such embodiments, the end of the flexible conduit  
21 can deflect if it impacts with the choke body (or  
22 any secondary conduit extending from the choke  
23 body). Thus in such embodiments, the flexible  
24 conduit ensures that the load carried by the frame  
25 is not transferred to the choke body.

26

27 Embodiments of the invention will now be described,  
28 by way of example only, and with reference to the  
29 following drawings, in which:-

30

31 Figure 1 is an elevational view of a subsea tree  
32 assembly, partially in section, and showing an

1 apparatus for connecting a flow interface to a  
2 subsea wellbore;

3

4 Figure 2 is an enlarged view, partially in section,  
5 of a choke body of the tree assembly and a lower  
6 portion of a mandrel of the apparatus of Figure 1;

7

8 Figure 3 is a top view of the tree frame of Figure  
9 1, with the connecting apparatus for the flow  
10 interface device removed;

11

12 Figure 4 is a top view of a lower frame member of  
13 the connecting apparatus of Figure 1;

14

15 Figure 5 is a sectional view of the lower frame  
16 member of Figure 4, taken along the line 5-5 of  
17 Figure 4;

18

19 Figure 6 is a top view of an upper frame member of  
20 the connecting apparatus of Figure 1;

21

22 Figure 7 is a partially sectioned view of the upper  
23 frame member of Figure 6, taken along the line 7-7  
24 of Figure 6;

25

26 Figure 8 is a schematic view of an alternate  
27 embodiment of a connecting system, shown prior to  
28 landing on the subsea tree assembly;

29

30 Figure 9 is a schematic view of the mounting system  
31 of Figure 8, with a lower frame member of the

1 connecting system landed on the subsea tree assembly  
2 and the upper frame member in an upper position;  
3

4 Figure 10 is a schematic view of the subsea tree  
5 assembly and the connecting system of Figure 8, with  
6 the upper frame member in a lower position;  
7

8 Fig 11 is a side view with interior details of a  
9 third embodiment of the invention;  
10

11 Fig 12 is an enlarged view in cross-section of a  
12 portion A of the Fig 11 embodiment;  
13

14 Fig 13 is a plan view of the Fig 11 embodiment;  
15

16 Fig 14 shows a series of views with cross-sectional  
17 details showing the Fig 11 apparatus being installed  
18 on a manifold;  
19

20 Fig 15 shows an enlarged view of Fig 14D;  
21

22 Fig 16 shows a side view of an embodiment similar to  
23 that of Fig 11, the frame also supporting a  
24 replacement choke; and  
25

26 Fig 17 shows an alternative embodiment similar to  
27 that of Fig 16, wherein an actuating means is  
28 provided to control the movement of a conduit means.  
29

30 Referring to Figure 1, production assembly 11 in  
31 this example includes a subsea Christmas tree 13.  
32 Christmas tree 13 is a tubular member with a tree



1 connector 15 on its lower end that connects to a  
2 wellhead housing (not shown) located on the sea  
3 floor. Tree 13 may be conventional, having a  
4 vertical bore with a master valve 17 and a swab  
5 valve 19. A production passage in tree 13 leads  
6 laterally to a production wing valve 21. Tree 13  
7 may be either a type having a tubing hanger landed  
8 within, or it may be a type in which the tubing  
9 hanger lands in the wellhead housing below the tree.

10  
11 A production choke body or receptacle 23 mounts to  
12 production wing valve 21. Choke body 23 comprises a  
13 housing for a choke insert (not shown) that is  
14 adjustable to create a back pressure and a desired  
15 flow rate. Choke body 23 connects to a production  
16 flow line 25 that leads to sea floor processing  
17 equipment or directly to a production facility at  
18 sea level. After being installed with a pressure  
19 intensifier, as will be subsequently explained, a  
20 choke insert may not be required. One use for the  
21 connecting apparatus of this invention is to  
22 retrofit existing trees that have previously  
23 operated without a pressure intensifier.

24  
25 Tree 13 may also have an annulus valve 27 that  
26 communicates with a tubing annulus passage (not  
27 shown) in the well. An annulus choke 29 connects to  
28 annulus valve 27 for controlling a flow rate either  
29 into or out of the tubing annulus. Annulus choke 29  
30 is normally located on a side of production assembly  
31 opposite production choke body 23. Annulus choke

1 29 has a body with a choke insert similar to  
2 production choke body 23.

3  
4 A tree cap 31 releasably mounts to the upper end of  
5 tree 13. A tree frame 33 extends around tree 13 for  
6 mounting various associated equipment and providing  
7 protection to tree 13 if snagged by fishing nets.  
8 Tree frame 33 is structurally connected to the body  
9 of tree 13, such that weight imposed on tree frame  
10 33 transfers to tree 13 and from there to the  
11 wellhead housing (not shown) on which tree 13 is  
12 mounted. Tree frame 33 has an upper frame member  
13 portion or plate 35 that in this instance is located  
14 above swab valve 19 and below tree cap 31. Upper  
15 plate 35 surrounds tree 13, as shown in Figure 3,  
16 and is generally rectangular in configuration. Tree  
17 frame upper plate 35 has a cutout 36 that provides  
18 vertical access to choke body 23 and a cutout 38  
19 that provides vertical access to annulus choke 29.

20  
21 As shown in Figure 3, preferably tree frame upper  
22 plate 35 has a plurality of guide members 37. Guide  
23 members 37 may vary in type, and prior to  
24 retrofitting with a pressure intensifier, were used  
25 to land equipment for retrieving and replacing the  
26 choke insert (not shown) in choke body 23 and in  
27 annulus choke 29. Although some subsea trees do not  
28 have any type of guide members, many do,  
29 particularly trees installed during the past 10-15  
30 years. In this example, each guide member 37  
31 comprises an upward facing cylinder with an open  
32 top. Guide members 37 are mounted in pairs in this

1 example with a locking member 39 located between  
2 them. Locking member 39 has a latch that latches  
3 onto a locking member inserted from above. Four  
4 separate sets of guide members 37 are shown in  
5 Figure 3, with one set located on opposite sides of  
6 cutout 36 and the other sets on opposite sides of  
7 cutout 38.

8  
9 Figure 3 also shows a control pod receptacle 40 that  
10 may be conventional. Control pod receptacle 40 has  
11 guide members 37 and locking members 39 for landing  
12 an electrical and hydraulic control pod (not shown)  
13 lowered from sea level. A plurality of guide posts  
14 41 are located adjacent sides of tree frame 33.  
15 Typically, each guide post 41 is located at a corner  
16 of tree frame 33, which is generally rectangular in  
17 configuration. Only one guide post 41 is shown in  
18 Figure 1, but the other three are the same in  
19 appearance. The existing guide posts 41 likely may  
20 not be long enough for the retrofit of a pressure  
21 intensifier in accordance with this invention. If  
22 so, a guide post extension 42 is installed over each  
23 guide post 41, and becomes a part of each guide post  
24 41. Guide post extensions 42 protrude upward past  
25 tree cap 31. A guideline 43 with a socket on its  
26 lower end slides over and connects to each guide  
27 post 41 or guide post extension 42, if such are  
28 used. Guidelines 43 extend upward to a platform or  
29 workover vessel at sea level.

30  
31 Still referring to Figure 1, a flow interface device  
32 lower frame member 45 lands on and is supported by

1 tree frame upper plate 35. In this embodiment,  
2 lower frame member 45 is a flat generally  
3 rectangular member, as shown in Figure 4, but it  
4 need not be a flat plate. A mandrel 47 is secured  
5 to one side of lower frame member 45. Mandrel 47  
6 has a tubular lower portion with a flange 49 that  
7 abuts and seals to a mating flange on choke body 23.  
8 Alternatively, mandrel 47 could be positioned on an  
9 opposite edge of lower frame member 45 and mate with  
10 the body of annulus choke 29, rather than choke body  
11 23.

12  
13 A clamp 51 locks flange 49 to the flange of choke  
14 body 23. Clamp 51 is preferably the same apparatus  
15 that previously clamped the choke insert (not shown)  
16 into choke body 23 when production assembly 11 was  
17 being operated without a pressure intensifier.  
18 Clamp 51 is preferably actuated with an ROV (remote  
19 operated vehicle) to release and actuate clamp 51.

20  
21 Referring to Figure 2, mandrel 47 has a lower bore  
22 52 that aligns with choke body vertical bore 53. A  
23 retrievable plug 55 is shown installed within a  
24 lower portion of choke vertical bore 53. A lateral  
25 passage 57 leads from choke body vertical bore 53  
26 above plug 55 to production wing valve 21 (Figure  
27 1). Plug 55 prevents fluid flowing down through  
28 mandrel 47 from entering flow line 25. Some  
29 installations have a valve in flow line 25  
30 downstream of choke body 23. If so, plug 55 is not  
31 required.

32

1 Referring to Figure 5, lower frame member 45 has a  
2 plurality of guide members 67 on its lower side that  
3 mate with guide members 37 of tree frame upper plate  
4 35 as show in Figure 3. Only one of the sets of  
5 guide members 67 is shown, and they are shown in a  
6 schematic form. Furthermore, a locking member 69  
7 protrudes downward from lower frame member 45 for  
8 locking engagement with one of the locking members  
9 39 (Figure 3) of tree frame upper plate 35. Lock  
10 member 69 is also shown schematically. Other types  
11 of locks are feasible.

12  
13 Lower frame member 45 also has guide post sockets  
14 71, each preferably being a hollow tube with a  
15 downward facing funnel on its lower end. Guide post  
16 sockets 71 slide over guide lines 43 (Figure 1) and  
17 guide posts 41 or extensions 42. Guide posts 41 or  
18 their extensions 42 provide a gross alignment of  
19 mandrel 47 with choke body 23 (Figure 1). Guides 67  
20 and 37 (Figure 1) provide finer alignment of mandrel  
21 47 with choke body 23 (Figure 1).

22  
23 Referring still to Figure 5, lower frame member 45  
24 also preferably has a plurality of upward facing  
25 guide members 75. In this example, guide members 75  
26 are the same type as guide members 37 (Figure 3),  
27 being upward facing cylinders with open tops. Other  
28 types of guide members may be utilized as well. In  
29 this instance, preferably there are four sets of  
30 guide members 75, with each set comprising two guide  
31 members 75 with a locking member 77 located between  
32 as shown in Figure 4. Guide members 75 are located

1 in vertical alignment with guide members 37 (Figure  
2 3), but could be positioned elsewhere. Lower frame  
3 member 45 also has a cutout 79 on one side for  
4 providing vertical access to annulus choke 29  
5 (Figure 3).

6  
7 An adjustment mechanism or mechanisms (not shown)  
8 may extend between lower frame member 45 and tree  
9 frame upper plate 37 to assure that the weight on  
10 lower frame member 45 transfers to tree frame upper  
11 plate 37 and not through mandrel 47 to choke body  
12 23. While the lower end of mandrel 47 does abut the  
13 upper end of choke body 23, preferably, very little  
14 if any downward load due to any weight on lower  
15 frame member 45 passes down mandrel 47 to choke body  
16 23. Applying a heavy load to choke body 23 could  
17 create excessive bending moments on the connection  
18 of production wing valve 21 to the body of tree 13.  
19 The adjustment mechanisms may comprise adjustable  
20 stops on the lower side of lower frame member 45  
21 that contact the upper side of tree frame upper  
22 plate 37 to provide a desired minimum distance  
23 between lower frame member 45 and upper plate 37.  
24 The minimum distance would assure that the weight on  
25 lower frame member 45 transfers to tree upper plate  
26 35, and from there through tree frame 33 to tree 13  
27 and the wellhead housing on which tree 13 is  
28 supported. The adjustment mechanisms could be  
29 separate from locking devices 69 or incorporated  
30 with them.

31

1 Referring to Figure 1, after lower frame member 45  
2 lands and locks to tree frame upper plate 35, an  
3 upper frame member 81 is lowered, landed, and locked  
4 to lower frame member 45. Upper frame member 81 is  
5 also preferably a generally rectangular plate, but  
6 it could be configured in other shapes. Upper frame  
7 member 81 has a mandrel connector 83 mounted on an  
8 upper side. Mandrel connector 83 slides over  
9 mandrel 47 while landing. A locking member 85,  
10 which could either be a set of dogs or a split ring,  
11 engages a grooved profile on the exterior of mandrel  
12 47. Locking member 85 locks connector 83 to mandrel  
13 47. A hydraulic actuator 87 strokes locking member  
14 85 between the locked and released positions.  
15 Preferably, mandrel connector 83 also has a manual  
16 actuator 89 for access by an ROV in the event of  
17 failure of hydraulic actuator 87. A manifold 91 is  
18 a part of or mounted to an upper inner portion of  
19 mandrel connector 83. Manifold 91 has a passage 93  
20 that sealingly registers with mandrel passage 52.  
21  
22 As shown by the dotted lines, a motor 95, preferably  
23 electrical, is mounted on upper frame member 81. A  
24 filter 97 is located within an intake line 98 of a  
25 subsea pump 99. Motor 95 drives pump 99, and the  
26 intake in this example is in communication with sea  
27 water. Pump 99 has an outlet line 101 that leads to  
28 passage 93 of manifold 91.  
29  
30 As shown in Figure 6, upper frame member 81 has four  
31 guide post sockets 103 for sliding down guidelines  
32 43 (Figure 1) and onto the upper portions of guide

1 posts 41 or guide post extensions 42. Upper frame  
2 member 81 has downward extending guide members 105  
3 that mate with upward extending guide members 75 of  
4 lower frame member 45, as shown in Figure 7.  
5 Locking members 107 mate with locking members 77  
6 (Figure 4) of lower frame member 45. Upper frame  
7 member 81 has a central hole 109 for access to tree  
8 cap 31 (Figure 1).

9  
10 Adjustable mechanisms or stops (not shown) may also  
11 extend between lower frame member 45 and upper frame  
12 member 81 to provide a minimum distance between them  
13 when landed. The minimum distance is selected to  
14 prevent the weight of pump 99 and motor 95 from  
15 transmitting through mandrel connector 83 to mandrel  
16 47 and choke body 23. Rather, the load path for the  
17 weight is from upper frame member 81 through lower  
18 frame member 45 and tree frame upper plate 35 to  
19 tree 13 and the wellhead housing on which it is  
20 supported. The load path for the weight on upper  
21 frame member 81 does not pass to choke body 23 or  
22 through guide posts 41. The adjustable stops could  
23 be separate from locking devices 107 or incorporated  
24 with them.

25

26 In the operation of this example, production  
27 assembly 11 may have been operating for some time  
28 either as a producing well, or an injection well  
29 with fluid delivered from a pump at a sea level  
30 platform. Also, production assembly 11 could be a  
31 new installation. Lower frame member 45, upper  
32 frame member 81 and the associated equipment would



1 originally not be located on production assembly 11.  
2 If production assembly 11 were formerly a producing  
3 well, a choke insert (not shown) would have been  
4 installed within choke body 23.

5  
6 To install pressure intensifier 99, the operator  
7 would attach guide post extensions 42, if necessary,  
8 and extend guidelines 43 to the surface vessel or  
9 platform. The operator removes the choke insert in  
10 a conventional manner by a choke retrieval tool (not  
11 shown) that interfaces with the two sets of guide  
12 members 37 adjacent cutout 36 (Fig. 3). If  
13 production assembly 11 lacks a valve on flow line  
14 25, the operator lowers a plug installation tool on  
15 guidelines 43 and installs a plug 55.

16  
17 The operator then lowers lower frame member 45 along  
18 guidelines 43 and over guide posts 41. While  
19 landing, guide members 67 and lock members 69  
20 (Figure 5) slidably engage upward facing guide  
21 members 37 and locking members 39 (Figure 1). The  
22 engagement of guide members 37 and 67 provides fine  
23 alignment for mandrel 47 as it engages choke body  
24 23. Then, clamp 51 is actuated to connect the lower  
25 end of mandrel 47 to choke body 23.

26  
27 The operator then lowers upper frame member 81,  
28 including pump 99, which has been installed at the  
29 surface on upper frame member 81. Upper frame  
30 member 81 slides down guidelines 43 and over guide  
31 posts 41 or their extensions 42. After manifold 91  
32 engages mandrel 47, connector 83 is actuated to lock

1 manifold 91 to mandrel 47. Electrical power for  
2 pump motor 95 may be provided by an electrical wet-  
3 mate connector (not shown) that engages a portion of  
4 the control pod (not shown), or in some other  
5 manner. If the control pod did not have such a wet  
6 mate connector, it could be retrieved to the surface  
7 and provided with one.

8  
9 Once installed, with valves 17 and 21 open, sea  
10 water is pumped by pump 99 through outlet line 101,  
11 and flow passages 93, 52 (Figure 2) into production  
12 wing valve 21. The sea water flows down the well  
13 and into the formation for water flood purposes. If  
14 repair or replacement of pressure intensifier 99 is  
15 required, it can be retrieved along with upper frame  
16 member 81 without disturbing lower frame member 45.

17  
18 An alternate embodiment is shown in Figures 8-10.  
19 Components that are the same as in the first  
20 embodiment are numbered the same. The mounting  
21 system has a lower frame member or frame portion 111  
22 and an upper frame member or frame portion 113.  
23 Jack mechanisms, such as hydraulic cylinders 115,  
24 extend between lower and upper frame members 111,  
25 113. Hydraulic cylinders 115 move upper frame  
26 member 113 relative to lower frame member 111 from  
27 an upper position, shown in Figures 8 and 9, to a  
28 lower position, shown in Figure 10. Lower frame  
29 member 111 preferably has guide members on its lower  
30 side for engaging upward facing guides on tree frame  
31 upper plate 35, although they are not shown in the  
32 drawings.

1  
2 Mandrel 117 is rigidly mounted to upper frame member  
3 113 in this embodiment and has a manifold portion on  
4 its upper end that connects to outlet line 101,  
5 which in turn leads from pressure intensifier or  
6 pump 99. Mandrel 117 is positioned over or within a  
7 hole 118 in lower frame member 111. When upper  
8 frame member 113 moves to the lower position, shown  
9 in Figure 10, mandrel 117 extends down into  
10 engagement with the receptacle of choke body 23.

11  
12 In the operation of the second embodiment, pressure  
13 intensifier 99 is mounted to upper frame member 113,  
14 and upper and lower frame members 113, 111 are  
15 lowered as a unit. Hydraulic cylinders 115 will  
16 support upper frame member 113 in the upper  
17 position. Guidelines 43 and guide posts 41 guide  
18 the assembly onto tree frame upper plate 35, as  
19 shown in Figure 9. Guide members (not shown)  
20 provide fine alignment of lower frame member 111 as  
21 it lands on tree frame upper plate 35. The lower  
22 end of mandrel 117 will be spaced above choke body  
23 23. Then hydraulic cylinders 115 allow upper frame  
24 member 113 to move downward slowly. Mandrel 117  
25 engages choke body 23, and clamp 51 is actuated to  
26 clamp mandrel 117 to choke body 23. Locks (not  
27 shown) lock lower and upper frame members 111, 113  
28 to the tree frame of tree 13.

29  
30 Figs 11 to 13 show a third embodiment of the  
31 invention. Fig 11 shows a manifold in the form of a  
32 subsea Christmas tree 200. The tree 200 has a

1 production wing branch 202, a choke body 204, from  
2 which the choke has been removed, and a flowpath  
3 leading to a production wing outlet 206. The tree  
4 has an upper plate 207 on which are mounted four  
5 "John Brown" feet 208 (two shown) and four guide  
6 legs 210. The guide legs 210 extend vertically  
7 upwards from the tree upper plate 207. The tree  
8 also supports a control module 205.

9  
10 Figs 11 and 13 also show a frame 220 (e.g. a skid)  
11 located on the tree 200. The frame 220 has a base  
12 that comprises three elongate members 222 which are  
13 cross-linked by perpendicular bars 224 such that the  
14 base has a grid-like structure. Further cross-  
15 linking arched members 226 connect the outermost of  
16 the bars 222, the arched members 226 curving up and  
17 over the base of the frame 220.

18  
19 Located at approximately the four corners of the  
20 frame 220 are guide funnels 230 attached to the base  
21 of the frame 220 on arms 228. The guide funnels 230  
22 are adapted to receive the guide legs 210 to provide  
23 a first (relatively coarse) alignment means. The  
24 frame 220 is also provided with four "John Brown"  
25 legs 232, which extend vertically downwards from the  
26 base of the frame 220 so that they engage the John  
27 Brown feet 208 of the tree 200.

28  
29 A processing apparatus in the form of a pump 234 is  
30 mounted on the frame 200. The pump 234 has an  
31 outlet and inlet, to which respective flexible  
32 conduits 236, 238 are attached. The flexible

1 conduits 236, 238 curve in a plane parallel to the  
2 base of the frame 220, forming a partial loop that  
3 curves around the pump 234 (best shown in Fig 13).  
4 After nearly a complete loop, the flexible conduits  
5 236, 238 are bent vertically downwards, where they  
6 connect to an inlet and an outlet of a piping  
7 interface 240 (to be described in more detail  
8 below). The piping interface 240 is therefore  
9 suspended from the pump 234 on the frame 220 by the  
10 flexible conduits 236, 238, and is not rigidly fixed  
11 relative to the frame 220. Because of the  
12 flexibility of the conduits 236, 238, the piping  
13 interface 240 can move both in the plane of the base  
14 of the frame 220 (i.e. in the horizontal plane of  
15 Fig 11) and in the direction perpendicular to this  
16 plane (vertically in Fig 11). In this embodiment,  
17 the conduits 236, 238 are typically steel pipes, and  
18 the flexibility is due to the curved shape of the  
19 conduits 236, 238, and their respective single  
20 points of suspension from the pump 234, but the  
21 conduits could equally be made from an inherently  
22 flexible material or incorporate other resilient  
23 means.

24  
25 A secondary conduit 250 is connected to the choke  
26 body 204, as best shown in Fig 15. The secondary  
27 conduit 250 comprises a housing 252 in which an  
28 inner member 254 is supported. The inner member 254  
29 has a cylindrical bore 256 extending therethrough,  
30 which defines a first flow region that communicates  
31 with the production wing outlet 206. The annulus  
32 258 between the inner cylindrical member 254 and the

1 housing 252 defines a second flow region that  
2 communicates with the production wing branch 202.

3  
4 The upper portion of the secondary conduit 250 is  
5 solid (not shown in the cross-sectional view of Fig  
6 15) and connects the inner member 254 to the housing  
7 252; the solid upper portion has a series of bores  
8 therethrough in its outer circumference, which  
9 provides a continuation of the annulus 258. The  
10 inner member 254 comprises two portions, for ease of  
11 manufacture, which are screwed together before the  
12 secondary conduit 250 is connected to the choke body  
13 204.

14  
15 The inner member 254 is longer than the housing 252,  
16 and extends into the choke body 204 to a point below  
17 the production wing branch 202. The end of the  
18 inner member 254 is provided with a seal 259, which  
19 seals in the choke body 204 to prevent direct flow  
20 between the first and second flow regions. The  
21 secondary conduit 250 is clamped to the choke body  
22 204 by a clamp 262 (see Fig 12) that is typically  
23 the same clamp as would normally clamp the choke in  
24 the choke body 204. The clamp 262 is operable by an  
25 ROV.

26  
27 Also shown in Fig 15 is a detailed view of the  
28 piping interface 240; the Fig 15 view shows the  
29 piping interface 240 before connection with the  
30 secondary conduit 250. The piping interface  
31 comprises a housing 242 in which is supported an  
32 inner member 244. The inner member has a

1 cylindrical bore 246, an upper end of which is in  
2 communication with the flexible conduit 238. An  
3 annulus 248 is defined between the housing 242 and  
4 the inner member 244, the upper end of which is  
5 connected to the flexible conduit 236. The piping  
6 interface 240 and the secondary conduit 250 have co-  
7 operating engaging surfaces; in particular the inner  
8 member 254 of the secondary conduit 250 is shaped to  
9 stab inside the inner member 244 of the piping  
10 interface 240. The outer surfaces of the housings  
11 242, 252 are adapted to receive a clamp 260, which  
12 clamps these surfaces together.

13  
14 The piping interface 240 is shown connected to the  
15 secondary conduit 250 in the views of Figs 11 and  
16 12. As shown in Fig 12, the inner member 254 of the  
17 secondary conduit 250 is stabbed inside the inner  
18 member 244 of the piping interface 240, and the  
19 clamp 260 clamps the housings 242, 252 together.  
20 The cylindrical bores 256, 246 are therefore  
21 connected together, as are the annuli 248, 258.  
22 Therefore, the cylindrical bores 256 and 246 form a  
23 first flowpath which connects the flexible conduit  
24 238 to the production wing outlet 206, and the  
25 annuli 248 and 258 form a second flowpath which  
26 connects the production wing branch 202 to the  
27 flexible conduit 236.

28  
29 A method of connecting the pump 234 to the choke  
30 body 204 will now be described with reference to Fig  
31 14.

32

1 Fig 14A shows the tree 200 before connection of the  
2 pump 234, with a choke C installed in the choke body  
3 204.

4

5 The production wing valve is closed and the choke C  
6 is removed, as shown in Fig 14B, to allow access to  
7 the interior of the choke body 204. This is  
8 typically done using conventional choke change out  
9 tooling (not shown).

10

11 Fig 14C shows the secondary conduit 250 being  
12 lowered onto the choke body 204. This can also be  
13 done using the same choke change out tooling. The  
14 secondary conduit 250 is clamped onto the choke body  
15 204 by an ROV operating clamp 262.

16

17 Fig 14D shows the secondary conduit 250 having  
18 landed on and engaged with the choke body 204, and  
19 the piping interface 240 being subsequently lowered  
20 to connect to the piping interface 240. Fig 15  
21 shows a magnified version of Fig 14D for greater  
22 clarity.

23

24 The landing stage of Fig 14D comprises a two-stage  
25 process. In the first stage, the frame 220 carrying  
26 the pump 234 is landed on the tree 200. The guide  
27 funnels 230 of the frame receive the guide legs 210  
28 of the tree 200 to provide a first, relatively  
29 coarse alignment. The John Brown legs 232 of the  
30 frame engage the John Brown feet 208 of the tree 200  
31 to provide a more precise alignment.

32



1 In the second stage, the piping interface 240 is  
2 brought into engagement with the secondary conduit  
3 250 and the clamp 260 is applied to fix the  
4 connection. The two-stage connection process  
5 provides protection of the mating surfaces of the  
6 secondary conduit 250 and the piping interface 240,  
7 and it also protects the choke 204; particularly the  
8 mating surface of the choke 204. Instead of landing  
9 the frame and connecting the piping interface 240  
10 and secondary conduit in a single movement, which  
11 could damage the connection between the piping  
12 interface 240 and the secondary conduit 250 and  
13 which could also damage the choke 204, the two-stage  
14 connection facilitates a controlled, buffered  
15 connection.

16  
17 The piping interface 240 being suspended on the  
18 curved flexible conduits 236, 238 allows the piping  
19 interface 240 to move in all three spatial  
20 dimensions; hence the flexible conduits 236, 238  
21 provide a resilient suspension for the piping  
22 interface on the pump 234. If the piping interface  
23 240 is not initially accurately aligned with the  
24 secondary conduit 250, the resilience of the  
25 flexible conduits 236, 238 allows the piping  
26 interface 240 to deflect laterally, instead of  
27 damaging the mating surfaces of the piping interface  
28 240 and the secondary conduit 250. Hence, the  
29 flexible conduits 236, 238 provide a buffering means  
30 to protect the mating surfaces.

31

1 A slightly modified version of the third embodiment  
2 is shown in Fig 16. The piping interface 240, the  
3 secondary conduit 250 and the tree 200 are exactly  
4 the same as the Fig 11 embodiment, and like parts  
5 are designated by like numbers. The piping  
6 interface 240 and the secondary conduit 250 are  
7 installed on the tree as described for the Fig 11  
8 embodiment.

9  
10 However, in contrast with the Fig 15 embodiment, the  
11 Fig 16 embodiment comprises a frame 320 that does  
12 not carry a pump. Instead, the frame 320 is  
13 provided with two flow hubs 322 (only one shown)  
14 that are connected to respective jumpers leading to  
15 a processing apparatus remote from the tree. This  
16 connection is typically done as a final step, after  
17 the frame has landed on the tree and the connection  
18 between the piping interface 240 and the secondary  
19 conduit 250 has been made up. The processing  
20 apparatus could be a pump installed on a further  
21 subsea structure, for example a suction pile. A  
22 replacement choke 324 is also provided on the frame,  
23 which replaces the choke that has been removed from  
24 the choke body 204 to allow for insertion of the  
25 inner member 254 of the secondary conduit 250 into  
26 the choke body 204.

27  
28 The replacement choke 324 is connected to one of the  
29 hubs 322 and to one of the flexible conduits 236,  
30 238. The other of the flexible conduits 236, 238 is  
31 connected to the other hub 322.

32

1 The Fig 16 frame is provided with a guide pipe 324  
2 that extends perpendicularly to the plane of the  
3 frame 320. The guide pipe 324 has a hollow bore and  
4 extends downwards from the frame 320, surrounding  
5 the piping interface 240 and the vertical portion of  
6 at least one (and optionally both) of the flexible  
7 conduits 236, 238; the guide pipe 324 has a lateral  
8 aperture to allow the conduits 236, 238 to enter the  
9 bore. The guide pipe 324 thus provides a guide for  
10 the piping interface 240 which protects it from  
11 damage from accidental impact with the tree 200,  
12 since if the frame 320 is misaligned, the guide pipe  
13 324 with impact the tree frame, instead of the  
14 piping interface 240. In an alternative embodiment,  
15 the guide pipe 324 could be replaced by guide  
16 members such as the guide funnels and John Brown  
17 legs of the Fig 11 embodiment. In further  
18 embodiments, both the guide pipe 324 and these  
19 further guide members may be provided.

20  
21 In use, the well fluids flow through the choke body  
22 240, through the annuli 258, 248, through flexible  
23 conduit 238 into one of the hubs 322, through a  
24 first jumper conduit, through the processing  
25 apparatus (e.g. a pump) through a second jumper  
26 conduit, through the other of the hubs 322, through  
27 the replacement choke 324, through the flexible  
28 conduit 236 through the bores 246, 256 and to the  
29 production wing outlet 206. Alternatively, the flow  
30 direction could be reversed to inject fluids into  
31 the well.

32

1 A further alternative embodiment is shown in Fig 17.  
2 This embodiment is very similar to the Fig 16  
3 embodiment, and like parts are designated with like  
4 numbers. In the Fig 17 embodiment, the second hub  
5 322 is also shown. In this embodiment, the guide  
6 pipe 324 surrounds only the flexible conduit 238,  
7 the other flexible conduit 236 only entering the  
8 guide pipe at the connection to the piping interface  
9 240.

10

11 The principal difference between the embodiments of  
12 Figs 17 and 16 is the provision of an actuating  
13 means, which connects the flexible conduit 238 to  
14 the frame to control the movement of the flexible  
15 conduit 238 and hence the position of the piping  
16 interface 240. The actuating means has the form of  
17 a hydraulic cylinder, more specifically, a swivel  
18 eye mounting hydraulic cylinder 326. The hydraulic  
19 cylinder 326 comprises two spherical joints, which  
20 allow the lower end of the hydraulic cylinder to  
21 swing in a plane parallel to the plane of the frame  
22 320 (the X-Y plane of Fig 17). The spherical joints  
23 typically comprise spherical eye bushes. The swivel  
24 joints typically allow rotation of the hydraulic  
25 cylinder around its longitudinal axis by a total of  
26 approximately 180 degrees. The swivel joints also  
27 typically allow a swing of plus or minus ten degrees  
28 in both the X and Y directions. Hence, the  
29 hydraulic cylinder 326 does not fix the position of  
30 the flexible conduit 238 rigidly with respect to the  
31 frame 320, and does not impede the flexible conduit

1 238 from allowing the piping interface 240 to move  
2 in all three dimensions.

3  
4 Fig 17A shows the hydraulic cylinder 236 in a  
5 retracted position for landing the frame 320 on the  
6 tree 200 or for removing the frame 320 from the tree  
7 200. In this retracted position, the flexible  
8 conduit 238 holds the piping interface 240 above the  
9 secondary conduit 250 so that it cannot engage or  
10 impact with the secondary 250 during landing.

11  
12 To make up the connection between the piping  
13 interface 240 and the secondary conduit 250, the  
14 hydraulic cylinder is extended; the extended  
15 position is shown in Fig 17B. In the extended  
16 position, the piping interface 240 now engages the  
17 secondary conduit 250. The pressure in the  
18 hydraulic cylinder 326 is now released to allow the  
19 clamp 260 to be actuated. The clamp 260 is actuated  
20 by an ROV, and pulls the piping interface 240 into  
21 even closer contact with the secondary conduit 250  
22 to hold these components firmly together.

23  
24 This invention has significant advantages. In the  
25 first embodiment, the lower frame member and mandrel  
26 are much lighter in weight and less bulky than the  
27 upper frame member and pump assembly. Consequently,  
28 it is easier to guide the mandrel into engagement  
29 with the choke body than it would be if the entire  
30 assembly were joined together and lowered as one  
31 unit. Once the lower frame member is installed, the  
32 upper frame member and pump assembly can be lowered

1 with a lesser chance of damage to the subsea  
2 equipment. The upper end of the mandrel is rugged  
3 and strong enough to withstand accidental impact by  
4 the upper frame member. The two-step process thus  
5 makes installation much easier. The optional guide  
6 members further provide fine alignment to avoid  
7 damage to seating surfaces.

8  
9 The movable upper and lower frame members of the  
10 mounting system of the second embodiment avoid  
11 damage to the seating surfaces of the mandrel and  
12 the receptacle.

13  
14 While the invention has been shown in only a few of  
15 its forms, it should be apparent to those skilled in  
16 the art that it is not so limited but is susceptible  
17 to various changes without departing from the scope  
18 of the invention. For example, although shown in  
19 connection with a subsea tree assembly, the mounting  
20 apparatus could be installed on other subsea  
21 structures, such as a manifold or gathering  
22 assembly. Also, the flow interface device mounted  
23 to the upper frame member could be a compressor for  
24 compressing gas, a flow meter for measuring the flow  
25 rate of the subsea well, or some other device.

26  
27 In the third embodiment, protection of the  
28 connection between the piping interface 240 and the  
29 secondary conduit 250 is achieved by the two-step  
30 connection process. Additional buffering is  
31 provided by the flexible conduits 236, 238, which  
32 allow resilient support of the piping interface 240

1 relative to the pump/the frame, allowing the piping  
2 interface 240 to move in all three dimensions. In  
3 some embodiments, even greater control and buffering  
4 are achieved using an actuation means to more  
5 precisely control the location of the piping  
6 interface 240 and its connection with the secondary  
7 conduit 250.

8  
9 Improvements and modifications can be incorporated  
10 without departing from the scope of the invention.  
11 For example, it should be noted that the arrangement  
12 of the flowpaths in Figs 11 to 17 are just one  
13 example configuration and that alternative  
14 arrangements could be made. For example, in Fig 16,  
15 the replacement choke could be located in the  
16 flowpaths before the first flow hub, so that the  
17 fluids pass through the choke before being diverted  
18 to the remote processing apparatus. The replacement  
19 choke could be located at any suitable point in the  
20 flowpaths.

21  
22 Furthermore, in all embodiments, the flowpaths may  
23 be reversed, to allow both recovery and injection of  
24 fluids. In the third embodiment, the flow  
25 directions in the flexible conduits 236, 238 (and in  
26 the rest of the apparatus) would be reversed.

27  
28 A replacement choke 324 could also be used in the  
29 other embodiments, as described for the Fig 16  
30 embodiment. The replacement choke 234 need not be  
31 provided on the frame.

32

1 All embodiments of the invention could be provided  
2 with a guide pipe, such as that shown in Fig 16.

3

4 In alternative embodiments, the actuating means of  
5 Fig 17 is not necessarily a swivel eye mounting  
6 hydraulic cylinder 326. In other embodiments, the  
7 hydraulic cylinder may only have a single swivelable  
8 connection, and in other embodiments, the hydraulic  
9 cylinder could have a reduced or even almost no  
10 range of movement in the X-Y plane. In further  
11 embodiments, this hydraulic cylinder could be  
12 replaced by a simple cable in the form of a string,  
13 which is attached to a part of the flexible conduit  
14 238. The flexible conduit 238 could then simply be  
15 raised and lowered as desired by pulling and  
16 releasing the tension in the cable. In a further  
17 embodiment, the hydraulic cylinder could be replaced  
18 by a screw jack, also known as a power jack, a first  
19 screw member of the screw jack being attached to the  
20 frame, and a second screw member being coupled to  
21 the flexible conduit 238. Operating the screw jack  
22 also raises and lowers the end of the conduit means,  
23 as desired.

24

25 Although the above disclosures principally refer to  
26 the production wing branch and the production choke,  
27 the invention could equally be applied to a choke  
28 body of the annulus wing branch.

29

30 In the Fig 11 embodiment, either of the conduits  
31 236, 238 could be attached to the inlet and the  
32 outlet of the pump 234 and either may be attached to



1 the inlet and the outlet of the piping interface  
2 240.

3  
4 Many different types of processing apparatus could  
5 be used. Typically, the processing apparatus  
6 comprises at least one of: a pump; a process fluid  
7 turbine; injection apparatus; chemical injection  
8 apparatus; a fluid riser; measurement apparatus;  
9 temperature measurement apparatus; flow rate  
10 measurement apparatus; constitution measurement  
11 apparatus; consistency measurement apparatus; gas  
12 separation apparatus; water separation apparatus;  
13 solids separation apparatus; and hydrocarbon  
14 separation apparatus.

15  
16 The processing apparatus could comprise a pump or  
17 process fluid turbine, for boosting the pressure of  
18 the fluid. Alternatively, or additionally, the  
19 processing apparatus could inject gas, steam, sea  
20 water, drill cuttings or waste material into the  
21 fluids. The injection of gas could be advantageous,  
22 as it would give the fluids "lift", making them  
23 easier to pump. The addition of steam has the  
24 effect of adding energy to the fluids.

25  
26 Injecting sea water into a well could be useful to  
27 boost the formation pressure for recovery of  
28 hydrocarbons from the well, and to maintain the  
29 pressure in the underground formation against  
30 collapse. Also, injecting waste gases or drill  
31 cuttings etc into a well obviates the need to

1 dispose of these at the surface, which can prove  
2 expensive and environmentally damaging.

3  
4 The processing apparatus could also enable chemicals  
5 to be added to the fluids, e.g. viscosity  
6 moderators, which thin out the fluids, making them  
7 easier to pump, or pipe skin friction moderators,  
8 which minimise the friction between the fluids and  
9 the pipes. Further examples of chemicals which  
10 could be injected are surfactants, refrigerants, and  
11 well fracturing chemicals. The processing apparatus  
12 could also comprise injection water electrolysis  
13 equipment.

14  
15 The processing apparatus could also comprise a fluid  
16 riser, which could provide an alternative route  
17 between the well bore and the surface. This could  
18 be very useful if, for example, the flowline 206  
19 becomes blocked.

20  
21 Alternatively, processing apparatus could comprise  
22 separation equipment e.g. for separating gas, water,  
23 sand/debris and/or hydrocarbons. The separated  
24 component(s) could be siphoned off via one or more  
25 additional process conduits.

26  
27 The processing apparatus could alternatively or  
28 additionally include measurement apparatus, e.g. for  
29 measuring the temperature/ flow rate/ constitution/  
30 consistency, etc. The temperature could then be  
31 compared to temperature readings taken from the  
32 bottom of the well to calculate the temperature

- 1 change in produced fluids. Furthermore, the
- 2 processing apparatus could include injection water
- 3 electrolysis equipment.